SEIS-UK

Fieldwork Procedures: CMG-3T and Taurus

Version 3.2

A. Brisbourne, A. Horleston, D. Hawthorn & V.Lane
March 30, 2012

Contents

1 Introduction

The Guralp CMG-3T when combined with the Nanometrics Taurus data-logger provides an easy to deploy broadband system. The Taurus is fully configurable without a palm or laptop greatly simplifying the deployment process. The Taurus records data to a removable 40Gb ATA drive which can record for over 600 days at 100 sps and can output data directly into miniseed format. Power consumption can be as low as 1.1 Watts and the unit will function at temperatures ranging from +5 to +55°C with magnetic disks, or down to −20°C with flash media. SEIS-UK can provide appropriate solar panels for almost any location in the world. The Guralp CMG-3T has low noise levels from 200s to 50Hz and power consumption < 0.75 W. No configuration of the CMG-3T is required although the user must remember to unlock the masses once the instrument is deployed.

This manual gives an overview of SEIS-UK's recommended procedures for a successful field project with the Taurus units and our Guralp CMG-3Ts. It covers the Taurus settings needed for this set-up but will not cover all the permutations available through the Taurus. Any different set-up needs should be discussed with SEIS-UK.

2 Brief Introduction to the Taurus

The Taurus will be supplied with an official Nanometrics manual which gives extensive details of the options available to the user. However, the units will be configured by SEIS-UK before each project so that the user should only have to check a few things in the field and it is these things that we will cover here.

The Taurus has an integrated screen and browser based configuration pages, accessed via 5 buttons on the front of the Taurus.

The Taurus also has 3 external status LEDs which give the user an immediate indication as to the status of the unit. These are found on the front panel, near the power socket and near the ethernet socket. The front LED and the power LED show the general status of the unit, the ethernet LED tells the user about the network configuration status. There is also a fourth LED by the disk slots inside the media door to show when the disk may be safely removed. These will all be discussed further in section 3.1.

The Taurus will record to both 1.8" disks and flash card media. The latter has a superior specification with regards temperature and altitude. We refer here in general to disk media. However, the media are interchangeable and in general the methodology presented here can be applied to both media types.

The Store works as a ringbuffer. It will wrap around when it is full and record over the oldest data that may be overwritten while preserving all data types. That is, the Taurus will select the oldest data block to overwrite as long as that is not the only data block for that band. If it is the only data block for that band, it will search for the next available data block to overwrite.

3 Huddle Test - Initial Instrument Set-up

The method outlined below is the recommended set-up procedure for the huddle test at the field-base. Forms are provided by SEIS-UK for the huddle test, field deployments and servicing of the instruments, and should be completed as each step is performed. The completion of these forms will ensure that all necessary parameters have been checked and will help us to diagnose any problems should they arise.

At the field base a huddle test should be performed to test the 3Ts and to check the configuration of the Taurus units. This gives the user a chance to familiarise themselves with the equipment, to check that each component is fully functional after shipping, and to make any configuration changes necessary so that no peripherals should be needed in the field deployments.

Each Taurus should be checked first without a sensor connected, so set up the hardware as follows:

1. Set up the sensors on a solid floor, away from draughts in the quietest place you can find.
2. Align them all to point in the same direction - preferably North but this is not essential as long as they are all aligned similarly.
3. Level the sensors using the three adjustable feet and the integrated bubble level. Once they are level lock the feet using the brass locking wheels.
4. Do NOT connect the instruments to the Taurus units yet.
5. Check that each Taurus has a 1.8" ATA hard disk in the media slot and that the media door is closed and secured. (To open the media door lift the handle and turn to vertical then push the handle down to the left.)
6. Connect a GPS antenna to each Taurus. If you can get the antennae out of a window, do so. If you are using a GPS repeater unit locate the antenna outside with a clear sky view and then mount the repeater unit inside so that it cannot see the external antenna but points towards the sensors. The repeater requires mains power.
7. Connect an ethernet cable to each Taurus and to the ethernet hub provided. The hub will need a mains power supply so connect this up too.
8. Connect the laptop ethernet cable to the hub and boot the laptop. Login as fieldusr.
9. Power up the Taurus units by connecting the power cables. You will need to run the instruments for up to 24 hours at the huddle test so make sure that batteries are fully charged or on mains chargers to prevent power failures.
10. **Please don't push any buttons as the units power up, just give them a few minutes to settle into a stable LED flashing state - see section 3.1 below.**
11. Note down all the serial numbers on the huddle test sheet.

3.1 Taurus LED states

As the Taurus boots, the status and ethernet LEDs change colour. Table 1 below (adapted from the Nanometrics manual) outlines the expected colours for the status LEDs.
Table 2 below gives the state and status of the Ethernet LED.

LED state	Unit status
Off	Digitiser is powered down.
Red	Digitiser is booting.
Blinking green	Unit is functioning properly. Slow blinking (once every 5 seconds) indicates normal operations. Fast blinking (once per second) indicates that the User Interface (UI) is starting up.
Blinking orange	At power-up this indicates that the unit is booting normally. After the initial boot sequence has finished this would represent a minor problem, e.g. the media door is open or the GPS lock is bad. The browser status page should give further information on the problem.
Blinking red	The unit is not operating fully due to a problem. This could be due to the GPS not being connected, the sensor not being connected (as in this case), the disk being full or absent, or a hardware or software problem. Check all hardware and if possible use the UI to check the status.

Table 1: Taurus status LEDs

LED state	Connection or networking status
Off	Processor is powered down.
Orange	Processor is booting.
Blinking green	Networking is configured and a carrier is detected.
Blinking orange	Networking is not configured.
Blinking red	Networking is configured but no carrier is found.

Table 2: Taurus ethernet LED

3.2 Initial Configuration Check

Having successfully powered up the units without the sensors connected the user must check the initial configuration. This is done to ensure that the Taurus and the sensor will not damage each other in any way. Once all the LEDs are flashing in a stable state (note that the primary `status` LEDs will be red since the sensor is not connected) there are two ways to access the units: the user may press and hold the central button on the Taurus for a couple of seconds, after which the screen should start (this may take a couple of minutes so be patient) or the user may open a web-browser on the laptop. When starting the screen in buffered mode the status LED will flash fast (once per second), then will go back to the slow flash and then the screen should come on.

Each Taurus has been set with a static I.P. address which will be displayed on the sticker on the front of the unit. These are also listed here in Table 3 (page 29), and will be bookmarked in the web-browser on the SEIS-UK laptop provided with the equipment. If accessing the units through the laptop (easiest for initial configuration at the field base but not recommended for deployment), point the web-browser to the I.P. address of the unit, e.g. for Taurus S/N 0293 go to http://143.210.23.139. This will bring up the status page for the unit. Firefox is the

recommended browser.

3.2.1 Navigating Through the User Interface

There are a couple of general points to note about the Taurus browser pages and their use:

- The browser pages seen on the laptop are identical to those seen on the Taurus display screen - the only difference is the way you navigate through them. On the laptop you can simply click on each link. On the Taurus itself the central button is used to select an option, the left and right buttons tab through the available options on a page and the up and down buttons scroll through the options in the drop down menu at the top of the display.
- The drop-down menu at the top left of the screen allows the user to navigate to a number of different pages.
- The serial number of the unit is always displayed in the top right-hand corner of the screen.
- Some pages have `Apply` and `Commit` buttons. Whenever making changes on these pages you must follow this procedure:

  1. Make the changes needed.
  2. Click on the `Apply` button and wait for a `Changes Applied` message.
  3. Click on the `Commit` button and wait for a `Successful commit` message.

  If either message is not seen then the change has probably not been applied and the above steps should be repeated.
- Some configuration changes require a `restart` of the unit but the screen will tell you this. To restart the unit navigate to the `Shutdown` page and select `Restart`.

There are a few pages that should be checked at this stage to ensure that the Taurus units are configured correctly for the CMG-3Ts and that the general hardware set-up is correct.

3.2.2 Unit Status

The first page to be seen when the Taurus User Interface is started is the status page. This page displays all the key information about the current status of the unit and will be the first page displayed whenever the unit is started.
Most fields are self-explanatory but just in case...

- The `Mode` line should be either `Buffered` which indicates that the Taurus will go into standby when the UI has not been accessed for 10 minutes. It will then buffer data and write to disk approximately every 30 minutes, or `Communications` in which case the unit will continuously stream data to the ethernet port and will also write to the disk continuously. The Taurus running alone in `Buffered` mode uses on average <1W, whereas `Communications` mode uses up to ∼3.3W. The sensor adds about another 0.75W.
- The `Store Time Left` value shows the amount of data that could be recorded if data was received at the same rate as it is now - since the only data recording now is internal noise, this is a long time! This number will obviously reduce considerably when an instrument is connect and will give a truer reflection of the recording time available.

- The `Store Size` line refers to the amount of disk space used. Typically we will aim to ship two clean disks per Taurus so you should expect this to show very little usage at the first huddle test. Note the total size displayed will not be 16Gb since some space is lost to formatting of the disk.
- The `IP` address shown is the static I.P. address and subnet mask assigned to the unit by SEIS-UK. This is where any bookmarks in the web-browsers on the SEIS-UK laptops will point to. It is advisable to keep this IP address unless you are putting the unit on a real-time network in another location. If the unit is to be deployed in stand-alone mode, do not change this address. If for any reason you change this, you will need to change the laptop network settings as well in order to talk to the unit.
- `Time` is the current date & time as supplied by the GPS antenna.
- `Voltage` is the power supply voltage - the Taurus has no internal batteries.
- `Power` is the current power usage of the unit. When the sensor is connected this number will include the total power usage of the Taurus and the sensor.
- `Packets` is the number of data packets received by the unit.
- `Timing` is the current timing uncertainty of the system clock.
- The `Status` bar refers to the overall status of the Taurus, including features such as store recording, door closed, GPS timing, sensor power, ethernet link, firmware, sensor control lines, power and system configuration. This should say *Status OK* in a green coloured status bar. In general green is fine and red is bad. A yellow status bar indicates that the Taurus is acquiring status information; this will change to green or red. You can click on the status line to see which features, if any, have problems. These will be covered in more detail below.
- Under the status bar, from left to right are:
  - Taurus serial number.
  - Total number of velocity channels being recorded & their sample rate.
  - Temperature of the Taurus. Unfortunately the analogue CMG-3T has no internal temperature recording available.

  By clicking the text within the status bar, the `Status Details` page will be displayed. If the status bar was yellow With a yellow or red status bar, you will be able to use this page to isolate the particular feature(s) causing a problem. Again,the boxes are colour-coded by the status of each of these features:

  - `Store` lets you know that the Taurus has a suitable writable disk installed and that this disk is formatted correctly. It will say *recording* if everything is ok. A red status bar indicates that the store is corrupt or missing, that the media is missing or that there is not enough free space for the chosen store size. In the field, a yellow status would suggest that the Taurus is re-indexing.
  - `Door` refers to the door to the media store at the end of the unit which should always be closed when in operation.

- `Time` refers to the GPS lock.
- `Sensor Power` tells you if there is power to the sensor - in this first test this box will be red since you should not have connected the sensor yet.
- `Link` displays the status of the ethernet connection when the Taurus is in communications mode (in buffered mode, with no ethernet connection, it will be green).
- `Firmware` checks the firmware version of all subcomponents match. If it is red, the versions do not match.
- `Sensor Control Lines` checks the sensor control configuration. If this is red, please check the settings in section 3.2.3 (page 8) very carefully. Remember to `Apply` & `Commit` any changes you make.
- `Power` lets you know if the power supply is adequate - the Taurus can run with a power supply between 9 and 36V although SEIS-UK regulators have a low-voltage disconnect function which kicks in when the battery voltage falls below 11.5V to preserve the batteries. The regulators will reconnect power once the batteries have reached 12.6V.
- `Config` tells you if the latest configuration changes have been commited (i.e. they will remain after a power cycle). If this is red, click on the text to move to the configuration page and commit the configuration.

Often a question mark will appear after the relevant text if there is a problem, e.g., `Door?` would imply that the door is not closed properly, and `Media?` would indicate that the Taurus cannot detect a suitable disk for recording.

If everything looks ok here then tick the box on the huddle test sheet and record which mode you are in (communications/buffered) and then proceed to the next section. If there are any problems check the following as appropriate:

- cables - are they all connected properly?
- does the GPS have a clear-sky view?
- have you inserted a disk into the disk drive?
- is the disk formatted? (Follow the instructions in section 9.)

If you need to change anything make a note on the huddle test sheet to show what you have done.

3.2.3 Check the Taurus is Expecting a CMG-3T

The following pages must be checked at the huddle test before the sensors are connected to ensure that the Taurus provides the correct power and control lines to the sensor and that the digitiser interprets the incoming data correctly.

1. **Check the `Sensor Details` page**
   - Login - eg as user `tech`
   - Go to `Configuration` > `Sensor Library`
   - Select seisuk CMG-3T from the list and check that page options are set as:

Sensor Name:	seisuk CMG-3T
SP/LP Mode:	LP
XYZ/UVW Mode:	XYZ
Calibration Mode:	Voltage
Needs Power:	√
Nanometrics Smart Sensor:	[Unticked]
Sensitivity Units:	V/(m/s)
Sensitivity Value:	1500

- If anything needs changing then remember to `Apply` and `Commit` your changes. Please let SEIS-UK know if any unit is not set up with these settings on arrival.
- If everything is ok, tick the 'Sensor' box on the huddle test sheet.

2. **From the `seisuk CMG-3T` page (you should still be on this page) select `Sensor Control Lines`**

   - This page should read as follows:

Assert (On) Level:	ZERO
Deassert (Off) Level:	HIGH Z
Positive Voltage Level [V]:	+12V
Pulse Duration [s]:	10
Ctrl Line 1 (pin H):	Mass Centre
Ctrl Line 2 (pin W):	Mass Unlock
Ctrl Line 3 (pin G):	Mass Lock
Ctrl Line 4 (pin Z):	Ch 1 Cal Enable
Ctrl Line 5 (pin c):	Ch 2 Cal Enable
Ctrl Line 6 (pin Y):	Ch 3 Cal Enable

   - Again, if you need to change anything remember to `Apply` and `Commit` your changes and to let SEIS-UK know.
   - If all is ok, tick the 'Control Lines' box on the sheet.
   - Use the `Previous` button to return to the `seisuk CMG-3T` page.

3. **Select `Auto Mass Centring`**

   - This page should read as follows:

Red Threshold [V]:	10.00
Auto-Centre on Red:	[unticked]
Yellow Threshold [V]:	4.00
Auto-Center on yellow:	√
Yellow Holdoff Time [h]:	1.00
Retries per Auto-Centre:	1
Retry Interval [min]:	1

   - `Apply` and `Commit` if you had to change anything.

- As always, if everything is correct, tick the relevant box on the test sheet.

4. **Return to the `Sensor Library` page either by selecting it through `Configuration` > `Sensor Library` from the drop-down menu or by selecting "Previous" twice.**

   - Check that the dropdown box at the top of the page says *seisuk CMG-3T* and that the `Apply` and `Commit` buttons at the bottom of the page are faded out. If this is not the case, select `seisuk CMG-3T` from the drop down menu, then select `Apply` and `Commit` (you may only have the option of selecting `Commit` if the library has been "applied" previously).

5. **Return to the main `Configuration` page either by selecting it from the drop-down menu or by selecting previous. Select `Digitizer` > `Front End`.**

   - Check this page is set up as follows:

`Input Range, diff p-to-p [V]:`	`40`
`Input Impedance:`	`Low`
`Common Mode Range:`	`Normal`
`Enable Dither:`	[unticked]
`Software Gain:`	`4.00`
`Enable Hard Clip:`	[unticked]

   - `Apply` and `Commit` any changes if necessary and tell SEIS-UK about them.
   - Note down the `Software gain` and `Input Range` values on the test sheet. This is vital for correct dataless seed production.

6. **Select `Previous` to return to the `Digitizer` page and then select `Main`.**

   - Select the `Sample Rate` you require.
   - The other settings should read:

`Output Channels:`	3
`Enable DC Removal:`	[unticked]
`DC Removal Cutoff [Hz]:`	0.001
`Frames Per Packet:`	7

   - `Apply` and `Commit` if any changes were made.
   - Record the sample rate being used on the test sheet.

7. **From the `Configuration` page select `General`**

   - Check the following setting:

`GPS Duty Cycle Mode:`	`Automatic`

   - If you require highly accurate timing it may be worth having the gps in `Always On` mode but this will increase the power consumption by by ∼200mW.
   - `Apply` and `Commit` any changes as usual.

- Note down the `Duty Cycle Mode` on the test sheet.

8. **If you want the unit to be discoverable,** `Enable Discovery`**.**
   - With Discovery enabled the Taurus will send out brief UDP messages to alert other programs to its presence. This may be useful if you are networking the Taurus units and running Apollo somewhere. However if the unit is not networked this will just lead to a continuous stream of alerts in the log files. As default we disable discovery. If you want to enable it follow the steps below.
   - Navigate to `Configuration` > `Communications` > `Discovery`.
   - Tick the `Enable Discovery` box.
   - `Apply` and `Commit`.
   - Always note down on the huddle test sheet whether Discovery is on or off.
9. **Navigate to Configuration > Power Manager**
   - This page details the internal low-voltage disconnect settings of the Taurus.
   - The default values will work well when running on a battery charged either from the mains or from solar panels with a solar regulator provided by SEIS-UK. If using any other regulators (or no regulators at all) please contact SEIS-UK for further advice. These values are set so that the Taurus can shutdown cleanly when a power failure is imminent preventing damage to the media store and prolonging battery life.
10. **Taurus Shutdown**
    - Having checked these pages and verified that the set-up is correct for use with a CMG-3T, each unit should be shut-down and powered-off and re-started with a sensor connected. It is important that the units are always shut-down cleanly before disconnecting the power supply else the data store may be corrupted.
    - To Shutdown the Taurus go to the `Shutdown` page available through the bottom link of the drop-down menu. This page gives two options which are explained on the screen.

3.3 Connecting and Testing the CMG-3Ts

Having checked that all the Taurus units are correctly configured, connect a levelled, oriented CMG-3T to each unit and power on. Again, you may have to wait a few minutes for each Taurus to boot up - don't press any buttons while it's booting, just give it time. Once all the LEDs are flashing green press and hold the centre button for about 1 second and then wait for the screen to start up.

As before the `Status` page should be the first screen displayed. Compare it to your notes from the previous testing. Since the configuration has just been checked the unit should now be showing the output from the sensor, however you may have to wait a little while for any waveforms to be visible as the sensor powers up.

3.3.1 CMG-3T Mass Unlocking

Once the system has safely powered up and the `Status` page reports power to the sensor, navigate to the `Sensor` page. This page gives all the salient information about the sensor. The mass status bars at the top show the position of the Z, N and E components (in that order). With the latest firmware version the green region shows when the masses are in a good functional range; the yellow region is the range within which the auto-center will kick in after a user-defined delay time; the red region is where the auto-center will start immediately.

1. Check the mass positions - when locked they should all be in the yellow range and at $\sim \pm$ 8V.
2. If this is the case, click on `Unlock` to start the unlocking process. The mass positions should update as the process progresses and the waveforms should show the impulsive signal being supplied.
3. Once the masses have settled, check that all three are in the green range of their status bars - if not `Center` them.
4. To lock the masses prior to moving the sensor simply click on `Lock` and wait until all masses have settled in the yellow region of the status bars around $\pm$8V. Always give them a few minutes to make sure that they are settled and safely locked.
5. Having unlocked the masses, check the waveforms and the instrument by doing a stomp test. The three streams may be viewed together directly on the `Sensor` screen or there is the option to enlarge them by displaying the `Waveform page`. The option to view one channel at a time does not appear to work in the current firmware release.

Below the `Unlock` button there is the option to turn the sensor `Off` - this will cut power to the sensor. NEVER DO THIS IN THE FIELD.

There are also buttons for supplying a calibration signal to the sensor from this page. This should not be required since calibration values for the CMG-3Ts are already known - if further information is required, please contact SEIS-UK.

3.3.2 GPS Timing

Navigate to the `Timing` page. Check that the time is correct and that the GPS has managed to establish a location (it will say 'N/A' if it has not managed to determine this yet). If the lock is not good check the `GPS Map` to see whether satellites in a particular area of the sky are not being received and if possible adjust the GPS location appropriately. Check the cable is securely connected and that there is no damage to the cable.

3.4 Quiet Time

Having checked the masses one last time and completed any appropriate fields of the Huddle Test sheet, leave the sensor recording overnight in a quiet place. In the morning:

1. Check the general status of the Taurus (`Status` page).
2. Check the GPS lock (`Timing` screen).

3. Check the mass positions and waveforms (`Sensor` page).
4. Check the `Data Availability`. This page should show the times that the Taurus recorded for. Hopefully there will be no gaps in the data.
5. If a linux PC is available, download the data using the procedure outlined in section 8 below and check the noise levels.
6. Swap the disk in the Taurus for the spare for each unit and leave to record for a short period of time to check that both disks are functional and correctly formatted.
7. Ensure that all fields of the Huddle Test Sheet have been completed.
8. When satisfied that all units are behaving correctly shut down the systems as follows:
   (a) From the `Sensor` page, lock the masses and wait to check that they are locked.
   (b) Go to the `Shutdown` page and `Shutdown` the Taurus. Wait until the screen has turned off and the LEDs are in the slow flash pattern.
   (c) Power down the Taurus and then disconnect the sensor.
   (d) Replace the dust cap on the sensor and retract the feet. Lock the feet in the retracted position. It is essential that the feet are always retracted for shipping.
   (e) Pack the Taurus and sensor away in the correct boxes ready for field deployment.

4 Field Deployment - Practicalities

The basic deployment of the Taurus and 3Ts is as for any other SEIS-UK broadband system. **The 3Ts require a solid base so site preparation prior to deployment is essential.** Various methods may be used depending on the site locations available. There is a recommended equipment list for deployments in Appendix C.

Before deploying anywhere you must gain permission from the land owner.

4.1 Bedrock

If bedrock is present, a pit should be dug to a depth of about 80-100 cm through the overburden down to the bedrock. The bedrock should then be flattened as much as possible and any loose rubble removed to leave a solid base. A concrete plinth, 2-3" deep should be prepared (50:50 sand:concrete) which must be less than the diameter of the pit lining (usually a bucket, drum or pipe). Mark a North-south line in the concrete before it sets. The pit liner can be installed at this point and the surrounds back-filled. Ideally the concrete should be left overnight to set to ensure that no further settling will occur. The concrete should be stirred well to remove any air bubbles. Accelerant can be used but this may result in differential expansion of the concrete.

Once the concrete is set (min. 4 hours) the sensor can be deployed as follows:

1. Before putting the sensor in the pit connect the sensor cable to the sensor and ensure the connection is tight. If the Taurus end of this cable is not yet connected to the you must protect it from mud/water by wrapping it in a bag or other suitable material. Dirty connections will lead to poor connections and probable instrument failure.

2. Align the sensor North/South - the brass pin is North.

3. Level the sensor and lock the feet (turn the locking cog clockwise to lock).

4. Fill the pit with insulation. This can be polystyrene beads but a better method is to use a liner that is just bigger than the sensor and then fill the gap between the liner and the pit wall with insulation material. This method means that no insulation is touching the sensor which isolates the sensor from any movement of the pit wall.

5. Test the sensor and set up - see the Deployment Sheet and the field methods in Section 5 below.

6. Once the setup has been tested, cover the pit with a suitable lid and then bury the top to provide thermal insulation.

7. If in a particularly wet area a drainage channel should be built to take excess water out of the pit. To do this, dig a channel downhill from the base of the pit and fill it with stones.

If the bedrock is at the surface this method can still be used but the sensor cover should be completely covered with rocks and soil to maximise thermal insulation and to reduce wind noise.

4.2 No Bedrock

If no bedrock is present, experiments have shown that it may be counter-productive to lay a concrete base. Whilst a concrete base is useful for levelling the sensor it does not improve the seismic signal. Burial of the sensor improves the very long period variation by significantly reducing the diurnal signal resulting from temperature variations. The major problem with this type of installation is the settling of the surrounding material. This should be compacted as much as possible at installation. Also changes in the water content of the surrounding soils may cause tilting. This is most likely in clay soils where cracking may occur.

Whenever bedrock is not available the following procedure should be followed:

1. A pit of 80 - 100 cm depth should be dug and all loose material removed from the base.
2. A 1" layer of clean sand should be placed at the bottom of the pit and gently firmed down.
3. A wooden beam (or similar) should be aligned North-south at the top of the pit before the sensor is installed.
4. The sensor should then be installed in a plastic bag with the feet fully retracted and the sensor cable already attached. Push the sensor into the sand to level it. Check it is aligned North-South.
5. Back-fill the pit using sand around the sensor. Tamp the sand down as you go so that it is firm. Be careful not to move the sensor while filling the pit - keep an eye on the alignment and levelling - the 3T is intolerant to tilt. Do not completely fill the pit yet.
6. Having 3/4 filled the pit power up the sensor and do all deployment checks - see the Deployment Sheet and Section 5 for further information.
7. Only once the system has been checked and is working properly, should you finish filling the pit.
8. After filling the pit always recheck the mass positions.

4.3 Taurus Field Deployment

Each Taurus is supplied in its own pelicase. Although the Taurus is waterproof the units should always be deployed in their cases since this will prevent them from getting damaged and should ensure that the units are dry when you come to service them and exchange the disks. The pelicases are black or yellow and they should be placed inside a plastic bag or, even better, a box, and then covered to help with security and insulation. The cases will provide some thermal insulation but in hot sunny climates and very cold areas it is recommended that the cases be shallowly buried to help stop the Taurus overheating or freezing.

4.4 Power in the Field

SEIS-UK can advise on the type and number of batteries and solar panels required for deployments - these will be dependent on the project area. All SEIS-UK panels are supplied with appropriate solar regulators which prevent over-charging and discharging of the batteries, prolonging battery life. The 6A regulators now shipped with the Taurus do not have an LVD.

The Taurus has a low-voltage disconnect setting so that it can shut itself down without damaging the data store and this will be set by SEIS-UK to be compatible with our regulators. If using any other regulators please contact SEIS-UK prior to deployment.

When using SEIS-UK regulators connections should be made in the following order:

1. Connect the battery to the regulator first - ensure the polarity is correct (red=positive).
2. Connect the solar panels next using the pair of ports on the side of the regulator. Make sure that any unused ports have proper waterproof caps fitted.
3. Connect the Taurus last to the load port of the regulator.

Solar panels can be mounted on wooden stands - appropriate materials are generally available in most areas and the user is responsible for providing these. A list of recommended materials is given in Appendix C.

4.5 Batteries

Battery size and solar panel requirements are dependent on location. SEIS-UK can recommend battery sizes and panel numbers using commercial software packages. In the field the battery may be buried beneath the solar panel stand along with the regulator.

It is advisable to charge all the batteries at the field base before you go out to the deployment sites. Even new batteries can often be considerably discharged.

4.6 Mains Powered Installations

In some locations mains power may be available for your sites. However, in this case SEIS-UK recommends using a triple-stage mains powered charger with a battery. This will ensure that the site will stay powered through temporary power cuts. SEIS-UK can provide suitable chargers on request so please let us know if you expect to have mains powered sites. The system should be set-up as folows:

1. Connect the triple-stage charger to the battery - we will provide flying leads with ring-crimp connectors on the end. If your batteries have unusual or particularly large terminals you made need to change the connectors. Be sure to connect the charger with the correct polarity. When it is connected, plug the charger into the mains socket and switch on if appropriate.
2. Once all other connections to the Taurus have been made as in the Deployment Procedure outlined in Section 5 connect the Taurus power cable to the battery.

As has been mentioned this set-up will prevent data loss through temporary power cuts and the Taurus low-voltage disconnect settings will protect the battery in the event of a long power cut. For those concerned, we have checked the charge dissipation from the battery to the charger and thus to the mains in the event of a power cut and this is minimal and so this configuration gives the best chance of continued data collection.

4.7 GPS

The Taurus is supplied with a Trimble GPS antenna. This can be mounted on a pole or bracketed to the solar panel supports (take care not to cast shadows on the solar panels). The GPS performs best with a clear sky view so the site should be chosen to try to provide this. If security is needed the antenna can be buried under a thin layer of soil but do remember to mark it's location so that you can find it again.

4.8 Cables

Damage to cables can often lead to a complete failure of a site. It is therefore very important that all cables are protected from the local wildlife. Exposed cables can also add to the noise of a site if they move about in the wind. All cables should be buried, preferably in plastic tubing (e.g. drain pipe) and a detailed sketch of the cable layout should be made to prevent damage when retrieving the instruments. Always try to leave a bit of slack on the sensor-Taurus cable to prevent the sensor being pulled. Try not to run the power cables next to the sensor-Taurus cables as this can introduce noise to the analog signal.

5 Field Deployment - Procedure

Make sure you have a copy of the SEIS-UK Taurus/3T Deployment Sheet with you - this form must be completed for every deployment. The procedure outlined here should take you through all the necessary steps to complete this form.

1. Prepare the site (preferably in advance) taking into consideration solar panel locations, gps location with clear sky view, drainage, insulation etc.
2. Fill in the first couple of sections of the deployment sheet if you have not already done so giving as much detail about possible noise sources or other pertinent information as possible. It is important to know as much as possible about the site and the soil around the sensor as this will aid diagnosis of any future problems such as tilting or unusual noise on the data streams.
3. Set up the solar panels and connect the battery and then solar panels to the regulator. This will allow the battery to charge (if it needs it) while you setup the rest of the instrumentation. Record the battery voltage and check that it is charging.
4. Deploy the sensor following the procedure outlined above in Section 4 but don't cover the pit yet. Remember to lock the sensor feet.
5. Note down the serial number of the sensor, Taurus and the removable Taurus disk.
6. Connect the sensor to the Taurus and then power it up. Be patient while it boots.
7. Once the status LEDs are in the slow flash pattern, press and hold the centre button to start the GUI if it doesn't start automatically.
8. Check the `Status` and `Status Details` pages (the latter is found by clicking the text in the main status bar) - is the timing ok? Is the door closed? Can the Taurus write to the media? Is the sensor powered? Record all values shown on these pages on the deployment sheet.
9. Navigate to the `sensor` page. Note the mass voltages prior to unlocking. Then `unlock` the masses and `center` if necessary. Record the new mass voltages once they are stable.
10. Navigate to the `Timing` page. Check that the GPS has a good fix. If not check the `GPS satellites` and `GPS map` pages for further information.
11. Navigate to the `Data Availability` page. Go to the current day and check that the Taurus is recording and has been since you started the instrument.
12. When satisfied that the Taurus is recording data, the sensor masses are stable and in the green range and the GPS has a good fix, cover over the sensor pit. Tidy up any loose cables and bury everything.
13. Complete all remaining fields of the deployment sheet.
14. If you have a camera it is advisable to take a photo of the site.

6 Service Procedure

With the Taurus' extensive recording capacity service trips for download purposes are not required as frequently as in previous setups. However, it is still important to check the sites on a regular basis to check that everything is still running ok. You may also want to retrieve the data so that you can start working on it.

The servicing procedure is straight-forward but should be done thoroughly otherwise problems with the site can be missed. You should always take and fill in a 'SEIS-UK Taurus and CMG-3T Servicing Sheet' to ensure that everything has been checked correctly. These are available from the SEIS-UK website. It is also worth taking the deployment sheet for the site with you when you service so that you can find everything easily and check anything that may have been anomalous then.

1. On arrival at the site record the site name, code, network code, servicing team members, latitude, longitude, altitude and the weather.
2. Before touching anything take a moment to survey the site visually - has anything changed? Is there any sign of disturbance or damage? If you have a camera take a photo.
3. Before approaching the Taurus itself, check the power supply. Record the battery voltage and check the LEDs on the regulator. If the battery voltage is low you may have trouble communicating with the Taurus since the extra power required to run the screen may trip the LVD on the regulator.
4. Note down the Taurus and Sensor serial numbers - you should know these from your deployment sheet.
5. Find the Taurus case and access the Taurus. Before pressing any buttons make a note of the LED states. Do not worry if the ethernet LED (on the side) is red - this is to be expected since there is no ethernet cable connected.
6. Press and hold the centre button for a few seconds to start the UI. Remember you'll have to wait a minute or two for the screen to start up. Do not press any buttons whilst the unit boots up.
7. Note down as much information as you can from the `Status` and `Status Detail` pages. Investigate any problems.
8. If everything is ok, navigate to the `Sensor` page and note down the masses and the power consumption of the sensor. Have a look at the waveforms.
9. If for any reason the masses are not within the green area issue a `center` command recording any actions taken. The masses should have auto-centered if they were outside the green area so this may indicate an underlying problem - possibly tilt of the instrument. Monitor the masses whilst you survey the site and check for any surface signs of possible tilt.
10. Navigate to the `Timing Screen` and check the timing status. Record as much information as you can about the GPS status.
11. Go to the `Data Availability` screen and record when you have data from and to. Be careful to note down any gaps.

- If there are gaps, look for patterns.
- Are there gaps at night? This would indicate power problems where the instrument is only running off the solar power.
- Are the gaps correlated to the darkest and/or coldest parts of the year? This would indicate a lack of sunlight or insulation meaning either that the instrument lost power or was too cold to operate. This could be confirmed by the logs and state of health files.

12. Once you have sorted any problems with the system you should shut it down and swap the disk. It is essential to shutdown the Taurus before removing the disk.

13. Go to the `Shutdown` page and select `shutdown`. Wait for the screen to go black and the LEDs to go to the slow flash pattern.

14. Open the media door (lift the handle, turn to vertical and push down) and check that the LED by the disk slot is green. If it is red do not remove the disk! Once the LED is green, remove the disk, replace it with the new one and close the media door. Note down the serial numbers of both disks.

15. Once the new disk has been inserted the Taurus user interface should restart. Once it does check that everything is functioning normally.

16. Check the data availability on the new disk. There should be new data from today. Note down any other data on the disk.

17. If there was a problem with the masses or the gps earlier go back now to check them again.

18. Check that the solar panels are clean.

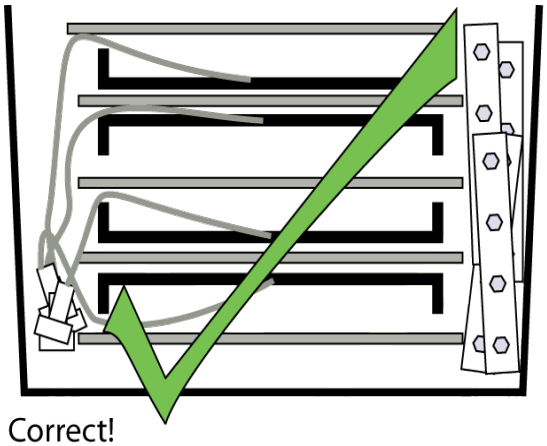
19. Check all the cables are secure and undamaged. Make safe any that may have come loose.

20. If you change the battery make a note of this for future reference.

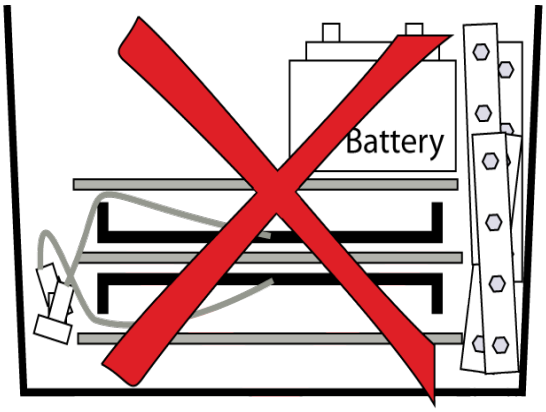
7 Site Decommissioning

At the end of each project the sites must be left in the state in which you originally found them. It is important to perform all the steps of the normal service procedure except for the disk swap at the pull-out since you still need to know how the instrument has been performing for the last few months.

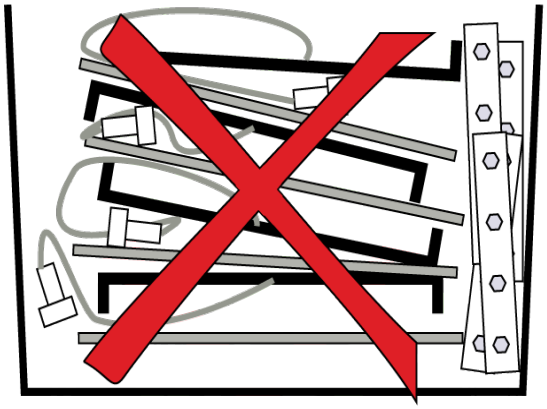
1. On arrival at the site for the pull-out do not start to dig anything up. First follow steps 1 to 8 above.
2. Once you have completed steps 1 to 8 and checked that the masses were ok during the recording period issue a `lock` command and wait until the masses have settled to around +/-8V.
3. Once you are certain that the masses are locked Shutdown the Taurus, disconnect the power and remove the disk. **Never move a sensor if the masses are not locked.**
4. You may then start to disassemble the site.
5. The sensors must have their feet retracted and locked in the retracted position before they are put in their carry cases. If this is not done the feet will get damaged in transit.
6. All items should be packed in their original packing materials.
7. Solar panels must be packed glass-to-glass and back-to-back with a sheet of foam between each one to avoid damage to the panels in transit. If the box is not full the panels must be strapped down or extra foam added on top to ensure that the panels cannot 'jump about' in transit. Never put anything heavy on top of the panels in the box - if it bounces it will break the panels.



Correct!
Panels back to back and face to face.
Bulgins down the side (not between panels).
Struts and clamps down the side.



WRONG!
Do not use the boxes for anything other than solar panels. Panels should be secured with foam, or the Velcro straps (if present).



WRONG!
Nothing should be between the panels.

Any panels already broken must be labelled, and seis-uk must be informed prior to shipping.

Panels must be packed face to face and back to back.

Panels must be securely held in place. This is especially important when the box is not full. In such cases the empty volume must be filled with foam, or the Velcro straps used.

Nothing (bulgins etc.) should be between the panels.

Cable tie the boxes shut for shipping.

PANELS BROKEN IN TRANSIT WILL BE CHARGED TO THE USER.

8 Data Download - Linux

Small sections of data may be downloaded direct from the Taurus to any laptop using the ethernet cable via the `Data Retrieval` page. However, for complete downloads the disk should be removed from the Taurus and the USB disk reader used with a linux PC or laptop.

The following procedure should be followed:

1. Boot linux laptop/PC and login.
2. If using an external hard-drive for data storage, connect it now. It should auto-mount - probably at `/media/disk`.
3. Insert Taurus disk into Taurus disk drive.
4. Connect Taurus disk drive to PC/laptop.
5. The device should auto-mount and icons should appear on the desktop. Check the location of the disk - probably something like `/media/disk-1` if you have already connected another external drive.
6. The disk directory should contain, amongst other things, a subdirectory `store`. File names in the store directory relate to the Taurus serial number.

A direct copy of the entire store should be made on your local disk or an external hard-drive - if using an external drive make sure you know which of your two mounted devices (/media/disk and /media/disk-1) is the Taurus disk and which is your external hard-drive. You should change into the external disk directory or a suitable place on the local disk and create a service directory and then, within this, sub-directories for each Taurus. Change into the Taurus directory for the store you have mounted and use "`cp -r`" to copy the entire store to this directory. You should always unmount the Taurus disk once you have finished using it.

The following example command line inputs assume that you are copying to an external hard-drive mounted as /media/disk and that the Taurus disk is at /media/disk-1 - **do not copy these commands blindly but make sure that you are referring to the correct devices**.

- `cd /media/disk`
- `mkdir SERVICE_1`
- `cd SERVICE_1`
- `mkdir TAURUS_805`
- `cd TAURUS_805`
- `cp -r /media/disk-1/* .`
- Then to unmount the Taurus disk:
  - `su -` [enter password]
  - `umount /media/disk-1`

- To read another disk, disconnect the disk reader, change disks and reconnect the disk reader and repeat the process. You may get an error message about the 'lost+found' on the new disk - this can be ignored.

Apollo Project should then be used to extract data and state of health from a copy of the store on the filesystem.

1. Attach the disk in the disk reader as above.
2. Start the "`firefox`" browser and enter "`http://localhost:8088`" in the address bar.
3. If the Apollo Project homepage does not appear then:
   (a) `su -`
   (b) `cd ~/ApolloProject`
   (c) `./ApolloProject &` - the last message you see from the output of this command should be `All post startup tasks complete`.
   (d) restart "`firefox`" and go to "`http://localhost:8088`"
4. Go to "`New`".
5. Name the project (i.e. ProjectName_QC) and select "One Time" from the list of radio button options. Select "OK".
6. Navigate to "Directory" (on the second row of tabs) and type in the full path to the basedir containing your stores. There is no auto-complete in this field, but the background colour of the box will become white when a valid path (with the correct permissions) has been entered. Once you have a valid path click "Add". Your stores should now be listed below, under "Selected Specifications".
7. Navigate to the "Channel Group Selection" tab (on the top row). Click "Create Default Station Table".
8. Navigate to the "Time Selection" tab (on the top row). Choose your start and end times and set the file interval to be 24 hours (use 12 hours for 200sps data).
9. Select the "Output Format" tab and choose `MiniSEED` > `Per channel`. Set the record size to 4096.
10. Select the "Output Location" tab.
    - Enter a base directory for the output data and SOH files. Again this will be red if an invalid path is given and white for a valid path.
    - Set Subdirectories: %year.%julian/
    - Set Filename: %time_%instrument_%channel
    - **Watch the placement of slashes in your path. A sample path is provided under the filename box. It should read something along the lines of baseDir/2011.028/time_taurus_serialNo_channel.**
11. Select "OK" at the bottom of the screen.
12. Select the "Run Now" option to start the conversion.

8.1 Field QC of Data

If you have a valid store you will be able to go to "`Data Retrieval`" from the Taurus user interface (in Firefox). SOH logs need to be downloaded to be QC'd. To do this from the data retrieval page:

- Click "Data Type: State of Health". Click "Next".
- Change "`Environment SOH`" to "`GPS Time`". Ignore "`available columns`" and "`selected columns`". Click on the "`next`" button to specify a time period and then download. Go back and repeat this process with "`instrument logs`" instead of "`GPStime`". The procedure for using these logs is described in the next section.
- If needed others SOH logs can be downloaded if time allows and/or problems are seen. These should all be renamed with the Taurus serial number for clarity (using the Choose Station Info link).
- In Firefox, the download destination directory can be set via the toolbar: Edit>Preferences>Main.

8.1.1 Viewing Apollo Project SOH Log Data

It is essential to check all data before leaving the field site - this way you can revisit any possible problem sites. We have a couple of scripts that make this process relatively easy and quick. You need to have copied the stores and extracted the Instrument and GPS SOH files to do this.
The script LOGplot.pl allows GPS and SOH data to be plotted. This script can be run by using:

LOGplot.pl <logs_dir> <option> <serial_no>

Where <logs_dir> must be the full path to the directory containing the SOH and GPS .csv files, <option> is a letter which specifies the type of plot required (as listed below) and <serial_no> is the serial number of the taurus unit you wish to plot data from.

Plot options are as follows:

- e Time error between system time and GPS time
- f Taurus system timing uncertainty
- g Taurus temperature
- h Power supply voltage (accurate to ±0.2V)
- i Taurus temperature and power supply voltage
- j Taurus sensor current

Check to see if the Sensor Current is reasonable - non-zero is a good start. Typically sensor current is around 80mA. Unlocking, locking or centering will see the current rise dramatically to anywhere between 300 and 800mA. You should be able to see if the sensor auto-centered during the recording period.

8.2 Full Extraction

Either back home or in the field a complete extraction of the data in miniseed format should be done. Yow will need to know the following:

- `Start-day` format is: 2005-08-21 (yyyy-mm-dd)
- `station-code` is the 4 or 5 digit code used to name your station
- `network-code` is the temporary deployment network code assigned by IRIS
- `channel-identifier` is BHZ if your sample rate is between 10 and 80 sps, or HHZ if your sample rate is >80 sps.

The station, net code and channel identifier are necessary for correct population of the miniseed headers.

Please refer to the data management manual for further details.

9 Formatting the 1.8" disks and flash cards

The 1.8" harddrives and flash cards should all be formatted as ext3 when they arrive in the field. If you do find a disk that is not formatted - the Taurus will complain that it cannot read the media - then follow this procedure to format it as an ext3 disk:

1. Insert the disk into the Taurus disk reader.
2. Connect the disk reader to the linux pc or laptop.
3. At a terminal enter the following:
   - > `su -`
   - > `fdisk -l` # This will list all devices - you are looking for the unformatted 16 or 40Gb device.
   - The disk has to be unmounted for this procedure. If the disk is mounted use `umount /dev/sd?1` to unmount it.
   - > `fdisk /dev/sd?` # Where sd? points to the disk found above.
   - > `n` # Create new partition.
   - > `p` # Primary partition.
   - > `1` # 1st partition.
   - Use enter on the next two options to select the default first and last cylinders. This will make this partition the size of the whole disk.
   - > `p` # Print out the partition structure. Check this is correct.
   - > `w` # Write the partition structure to the disk.
   - > `mkfs.ext3 /dev/sd?1` # Create the ext3 file system on the newly formatted partition. This may take some time.
   - If you see the message `/dev/sd? is mounted; will not make a file system` it means that the newly formatted disk has auto-mounted. Use the `umount /dev/sd?1` command and try the `mkfs.ext3` command again.
   - > `fdisk -l` # Should now list the disk as a linux formatted 16 or 40Gb device.
4. Remove the disk and insert the next unformatted device if you have another.

10 Problems - Q&A

1. **The Taurus configuration is wrong, what should I do?**
   - Contact SEIS-UK.
   - Connect the Taurus to the laptop (if not already done).
   - Go to the Configuration page and browse for the text formatted configuration file on the laptop with the correct Taurus serial number (should be called e.g. taurus_sn0295_config.txt or .conf) as advised by SEIS-UK.
   - Click 'Upload' followed by 'Commit'. This may take some time and after a successful upload the Taurus will restart itself to initialise the new configuration.
   - Check that the configuration is now correct. If not contact SEIS-UK again.

2. **My Taurus has died and I need to move the sensor, how do I lock the masses?**

   SEIS-UK will have provided two external control boxes for the CMG-3Ts. These have their own power cable and a cable converter box. The Sensor cable should be disconnected from the Taurus and connected into the converter box which should then be connected into the end port of the hand control unit. The hand control unit should be powered using the cable provided - this will power the sensor too. Use the switches to check the mass positions and then lock the masses of the 3T. You need to hold the switches for up to 10 seconds to initiate the lock. Unfortunately the 'busy' light will not come on even when the masses are unlocking/locking but you will see the mass position voltages fluctuate on the display of the control unit. Ensure that all three masses are at +/-8V before powering off the control unit and moving the sensor.

3. **What's this 'Make store read only' option?**

   This button makes the Taurus store read only, even if you change the disk. **DON'T DO THIS** or you will not record any data.

4. **My Taurus won't unlock the sensor - what do I do?** Occasionally one or more of the 3T masses will not unlock when asked to. Try again to unlock but if this gives no better results you will need to use the external break-out box provided. Connect the sensor to the breakout box via the cable converter unit and then connect the power cable to the break-out box and to the battery. Use the levers on the breakout box to unlock the masses - you must press and hold the 'enable' and 'unlock' switches together until the voltages start to fluctuate - the LED will not work when you are using the cable converter. Once the voltages of the mass positions start to move you can release the switches. Center if necessary using the centering switch. This same procedure can be used to lock the masses if the Taurus fails (see above).

Appendix A Taurus Static I.P. Addresses

As previously mentioned each Taurus has been assigned a static I.P. address by SEIS-UK. These should not be changed in the field without prior consultation with SEIS-UK. They are listed below in Table 3.

Serial Number	Static I.P. Address
SN0282	143.210.23.138
SN0293	143.210.23.139
SN0295	143.210.23.143
SN0297	143.210.23.144
SN0302	143.210.23.145
SN0818	143.210.23.134
SN0832	143.210.23.136
SN0781	143.210.23.146
SN0805	143.210.23.135
SN0770	143.210.23.133
SN0786	143.210.23.147
SN0789	143.210.23.148
SN1025	143.210.23.172
SN1030	143.210.23.174
SN1032	143.210.23.173

Table 3: Taurus static I.P. addresses

Appendix B What to do if seisuk CMG-3T is missing from the sensor library

If, having navigated to the `Sensor Library` page (Configuration > Sensor Library), you find that the seisuk CMG-3T Library configuration is missing, you will need to complete the following steps:

1. Select the "Copy" icon (which looks like 2 sheets of paper) next to the `Default CMT-3T` configuration file in the list and set the following:

`Sensor Name:`	`seisuk CMG-3T`
`SP/LP Mode:`	`LP`
`XYZ/UVW Mode:`	`XYZ`
`Calibration Mode:`	`Voltage`
`Needs Power:`	$\surd$
`Nanometrics Smart Sensor:`	[Unticked]
`Sensitivity Units:`	`V/(m/s)`
`Sensitivity Value:`	`1500`

   - Select the `Apply` button and once confirmed, select the `Commit` button and wait for confirmation of a successful commit.

2. Navigate to `Sensor Control Lines` from the link at the bottom of the page:
   - This page should read as follows:

`Assert (On) Level:`	`ZERO`
`Deassert (Off) Level:`	`HIGH Z`
`Positive Voltage Level [V]:`	`+12V`
`Pulse Duration [s]:`	`10`
`Ctrl Line 1 (pin H):`	`Mass Centre`
`Ctrl Line 2 (pin W):`	`Mass Unlock`
`Ctrl Line 3 (pin G):`	`Mass Lock`
`Ctrl Line 4 (pin Z):`	`Ch 1 Cal Enable`
`Ctrl Line 5 (pin c):`	`Ch 2 Cal Enable`
`Ctrl Line 6 (pin Y):`	`Ch 3 Cal Enable`

   - These should all be defaults but if you need to change anything remember to `Apply` and `Commit` your changes and let SEIS-UK know.
   - Use the `Previous` button to return to the `seisuk CMG-3T` page.

3. Select `Auto Mass Centring`
   - This page needs to be set as follows:

`Red Threshold [V]:`	`10.00`
`Auto-Centre on Red:`	[unticked]
`Yellow Threshold [V]:`	`4.00`

Auto-Center on yellow:	√
Yellow Holdoff Time [h]:	1.00
Retries per Auto-Centre:	1
Retry Interval [min]:	1

- Select `Apply` and then `Commit`.

4. Return to the `Sensor Library` page either by selecting it through `Configuration` > `Sensor Library` (from the drop-down menu) or by selecting "previous" twice. Select the newly created `seisuk CMG-3T` configuration file from the drop down list and hit `Apply`. Once applied, select `Commit` to make the change permanent. **Warning: Failing to select Apply and Commit will cause the configuration to be lost following a reboot.**

5. Return to the Huddle Test section of the manual (section 3, page 4) to complete all the necessary system checks.

Appendix C Recommended Equipment and Tools

C.1 Wooden Solar Panel Stands - Per Site

Wooden solar panel stands are quick and simple to install and materials can be purchased in the field.

To support 2 x 36W Solar Panels - 4 stakes hammered into the ground, with two supports running the length of the panels, battery / regulator stored beneath.

2 x	1.2m lengths of 2"x1" timber
2 x	1.0m lengths of 2"x2" timber (shaped to a point at one end to form stakes)
2 x	0.5m lengths of 2"x2" timber (shaped to a point at one end to form stakes)
16 x	1" self tapping wood screws
8 x	2.5" self tapping wood screws
2 x	Battery terminals per battery - preferably screw type- with bolts for M6 crimp terminals

Please contact SEIS-UK to confirm your solar panel requirements and we will advise on dimensions should you not be using 2 x 36W panels.

C.2 Sensor Pit

Pit design is site specific. If bedrock is present, a pit (∼1m deep) should be dug down to the bedrock, a concrete plinth built and the sensor stood directly on top. If no bedrock is available e.g. volcanics / sands, the sensor is simply buried inside a plastic bag.

Bedrock - Concrete Plinth

Concrete / Sand (mix 50:50) / Accelerant - or quick-dry ready-mix cement
Approx. 16" diameter plastic bin/pipe with lid
Polystyrene beads or other insulating material to insulate pit

No Bedrock - Burial

Heavy duty plastic bag
Clean sand / Concrete slab - to form a firm base

C.3 Taurus

The Taurus is in a pelicase but should still be protected and hidden wherever possible. We recommend for long deployments that a plastic storage box be used (if you can find one big enough) to house the Taurus case and the battery and regulator - you may need to use two separate boxes. The box/boxes can then be buried so that the top is at surface level. The whole box may then be covered with a tarpaulin and a thin layer of soil/stones. This will provide protection from water penetration and will make the box easy to find again. This is a much better solution than using plastic bags which degrade and get ripped allowing water and mud to penetrate.

It is worth thinking about insulation - both in hot and cold climates - for both the batteries and the Taurus. Burial can help considerably with maintaining a constant temperature but in cold climates extra insulation may be required. If you need any further advice on optimum deployment materials for the Taurus please contact SEIS-UK.

C.4 General Tools - One set per deployment team/vehicle

Solar Panel Stand	**Sensor Pit**
7lb Sledgehammer (optional)	Spade
Wood Saw	Metal Spike or Pick Axe
Wire Strippers *	Chisel / Lump Hammer / Goggles - if bedrock)
Small Screwdriver *	Bucket (concrete mixing)
Large Screwdriver *	Compass
Knife *	Water (jerry cans)
Crimp Tool **	Trowel (to mix concrete/bury cables)
Crimps	Spirit Level *
Digital Voltmeter *	Tape Measure *
Power Drill / Driver (recommended) **	

* Items usually supplied with SEIS-UK equipment - check how many if you have a number of deployment teams.

** Items may be supplied by SEIS-UK upon request.

A general purpose toolkit is available from SEIS-UK - please contact us for further details.

C.5 General Supplies

The list below includes the most common extras used in broadband deployments. This list is not exhaustive so remember to think about the local conditions - temperature, humidity etc.

Duck & Insul. Tape	Plastic Bags (sensor / SAM)	Concrete etc
Cable Ties	Polystyrene Beads	Plastic Bins / Buckets
Choc Blocks	Sand / Crusher Dirt	Spare Mains Cable